International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

Herbs Used for the Treatment of Anti-Diabetes

Komal Umesh Kanthale

Submitted: 05-02-2023 Accepted: 20-02-2023

I. INTRODUCTION

The traditional knowledge on medicinal plants is by the main basis of bio cultural and ecosystem conservation as well as further Pharmacological, Phytochemical, Toxicological and Ecological studies.[1] Traditional medicinal plants widely used and accounts for around 40% of all health care delivered.[2] From the past few years there has been an exponential growth in the field of herbal medicine and these herbs are increasing popularity in all over world because of their natural origin and less side effects. Herbal medicines have good values in treatment in many countries, scientific investigation of Medicinal plants have been initiated because of their potential.[3] Traditional medicine and ethnos botanical information play an important role in scientific research.[4,5] In India indigenous medicines have been used in the treatment of Diabetes mellitus since the time of Charaka and Sushruta (6th century BC).[6] According to WHO estimations, more than 80% of the world population depends on traditional medicinal practice for primary health care needs.[7] Over 75% of the world population is depending on local health practioners and traditional medicines for their primary needs.[8]

Diabetes mellitus is a very common metabolic disorder which affects the human population throughout the world, characterized by hyperglycaemia and arises due to defects in insulin secretion, insulin action or both. Chronic hyperglycaemia which is a common effect of uncontrolled diabetes causes long-term damage, dysfunction and failure of several organs such as kidneys, eyes, nerves, heart and blood vessels[9]. Diabetes is mainly categorized into two types, type-I diabetes and type-II diabetes.

Type-I diabetes is known as insulin dependent diabetes and characterized by zdeficient production of insulin, requires daily administration of insulin. This happens due to the cellular mediated autoimmune destruction of the b cells of pancreas.

Type-II diabetes commonly known as non-insulin dependent diabetes which causes due to the ineffective use of the insulin by the body. The following risk factors are commonly involved in the development of type-II diabetes such as genetic factors, obesity, poor diet, insufficient physical activity, advancing age, hypertension etc.[10- 11] There is a another class of diabetes is reported known as gestational diabetes which mainly arises from glucose intolerance, with an onset during pregnancy. This is a temporary condition but it may carries the long term risk of diabetes[12]

Many drugs are used conventionally for the prevention and management of diabetes such as biguanides, sulfonylureas, meglitinides, PPAR-γ agonists (glitazones), α- glucosidase inhibitors, DPP-4 inhibitors, SGLT2 inhibitors, dopamine-2 agonists etc. But still effective treatment against diabetes yet to be achieved[13]. Research is going on for establishing alternative effective therapies against diabetes. The medicinal plants played an important role in this research as they always are an exemplary source of drugs. In India many herbs are found to be useful for the management of diabetes.

From the ethnobotanical information it is found that approximately 800 plants may possess antidiabetic potential. From the knowledge and detailed survey of the medicinal plants we might be able to discover new drugs which are therapeutically active and also cheaper. There are certain advantages of using herbs in the treatment, such as they are easily available, low side effects etc.

II. INDIAN MEDICINAL PLANTS WITH ANTIDIABETIC POTENTIAL

Sr. no	Botanical name(common name)	Family	Plant part	Chemical constituents	Pharmacological activity as antidiabetic
1	withania coagulans	Solanaceae	Flower and fruits	d-galactose , d-arbinose	Hypoglyce mic and anti - oxidant activity

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

					● Anti-hyperglyce mic activity
2	Momordica charantia (bitter melon)	Cucurbitacea e	fruit	Charantin,5-hydroxy tryptamine	● Anti - Hypoglyac emic effect
3	Pterocarpus marsupium (vijaysar)	fabaceae	bark	Isoliqiritigenin, liquiritigenin	● Anti-hyperglyce mic activity
4	Aegle marmelos (Bilva)	rutaceae	leaf		● Anti - Hypoglyce mic effect
5	Syzygium cumin (jambolana)	myrtaceae	Seed and pulp	anthocyanins	● Hypoglyce mic and anti - oxidant activity ● Anti- hyperglyce mico activity
6	Ocimum tenuiflorum (Tulsi)	lamiaceae	leaf	Terpenoids, Arestrictil B	● Hypoglyce mic effect
7	Trigonella foenum-graecum (fenugreek,)	fabaceae	seeds	4-hydroxyisoleucine	● Anti - Hypoglyce mic effect
8	Gymnema sylvestre (gurmar)	apocynaceae	leaf	Gymnemic acid	● Anti – hyperglyce mic effect
9	Azadirachta indica	meliaceae	leaf	Nimbidin, nimbin, nimbidol	Anti- hypoglycemic effect

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

1. withania coagulans

Withania is a small genus that belongs to a diverse family of shrubs Solanaceae (comprising approximately 2000–3000 species distributed

across 90 genera) [14]. Different species of Withania are widely distributed across the East Mediterranean to South Asian regions. Pakistan is home to its two species W. coagulans and W. somnifera [15].

Fig –1 [W. Coagulans]

The genus Withania, particularly W. coagulans, is well-known for its diverse biological potential. According to the literature, different parts of the plant are used against impotence, wasting diseases, failure to thrive in children, insomnia, and nervous exhaustion. For instance, the active principle of its seeds is used in traditional medicines, and is responsible for milk coagulation[16] . Similarly, the sweet fruit of this plant has been found to be helpful against liver complications, asthma, and biliousness, as well as, it is found to be emetic, diuretic, and sedative. The flowers of W. coagulans are used in the treatment of diabetes. Apart from ethnobotanical applications, several therapeutic applications of this plant have been reported, including antihyperglycemic, anti-inflammatory, antitumor, antimicrobial, hepatoprotective, cardiovascular, immuno-suppressive, free radical scavenging, and central nervous system depressant activities [17,18,19]Moreover, antimutagenic, antidiabetic, and leishmanicidal activities have also been described for this plant.[20,21]

The major bioactive phytoconstituents isolated from W. coagulans are lactone steroids called as withanolide. Withanolides have C-28 ergostane steroidal nucleus with γ- or δ-lactone, and a side-chain connected to the C-17 carbon atom. According to the literature, withanolides have only been slightly explored in plants bearing withanolide and related ergostane-type steroids.

α-Glucosidase (EC3.2.1.20) is a small intestinal-membrane bound enzyme which catalyzes the hydrolysis of an oligosaccharide to absorbable monosaccharide, i.e., glucose, and thus its inhibition can suppress the postprandial hyperglycemia. Therefore, inhibition of α-glucosidase is a useful intervention to manage type II diabetes. Moreover, α-glucosidase antagonists have also been used as anti-obesity drugs, inhibitors of tumor metastasis, insect's antifeedants, antiviral, and fungistatic compounds, and immune modulators

Based on antidiabetic and antiglycation potential of W. coagulans current study was aimed to identify active constituents responsible for these activities. Additionally, the binding orientation of investigated compounds with α-glucosidase were investigated through molecular dynamics simulations and binding site residues responsible for inhibitor binding were also elucidated.

2. Momordica charantia L

Momordica charantia (MC) is one of the most common vegetables in the tropical region, particularly in Vietnam, India, China, East Africa, South–North Asia, and Central and South America [22'23]. It is a member of the Cucurbitaceae family and is known as bitter melon or bitter gourd. Besides using MC as a vegetable, it is supposed to be a herbal medicine, used as folk medicine. Its bioactivities, such as anti-inflammatory activity, anti-oxidant activity, anti-viral activity, anti-cancer activity, anti-bacterial activity, etc. and especially anti-diabetic activity [24].

Fig-2 [Momordica charantia]

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

Antidiabetic Activity

The fruits, seeds and callus of Momordica charantia contain some insulin-like proteins [25] which are homologous to human insulin, and it produced consistent hypoglycemic effect when tested on rats, gerbils, langurs and human beings [26]. In India and China, MC was believed to be a treatment for diabetes mellitus for thousands of years. Nowadays, scientists have done many types of research focusing on its anti-hyperglycemic abilities. Indeed, many research papers have shown that its bioactivities decrease significantly in blood glucose levels. These investigations on bitter melon also demonstrated that it can enhance the glucose tolerance of normal and diabetic mice and also in humans [27,28,29,30,]. Many studies proved that bioactive constituents for MC have considerable antidiabetic activities .

fig-3 [antidiabetic activities.]

phytochemistry

There were many investigations publishing active components of bitter melon that support type 2 DM treatment. The important phytochemicals of the plants are steroids, momordicosides (A, B, C, D, E, G, F_1, F_2, I, K, L), acyl glucosyl sterols, fatty acids, amino acids, alkaloids, phenolic compounds, steroidal saponin, vitamins, carbohydrates, and minerals, etc.

3. Pterocarpus marsupium Roxb.

Pterocarpus marsupium Roxb. (Family Fabaceae) is a large tree that commonly grows in central, western and southern parts of India and Sri Lanka. It is also known as Bibla or Vijaysaar in Hindi, Sarfaka in Sanskrit and Indian kino in English. Kino is the dried exudation obtained by incising the trunk of the plant and is traditionally used as an astringent and anti diarrheal agent. Overnight water stored in tumblers made out of the heartwood of P. marsupium is used as traditional therapy for the patients of diabetes mellitus especially in state of Madhya Pradesh.[31,32]

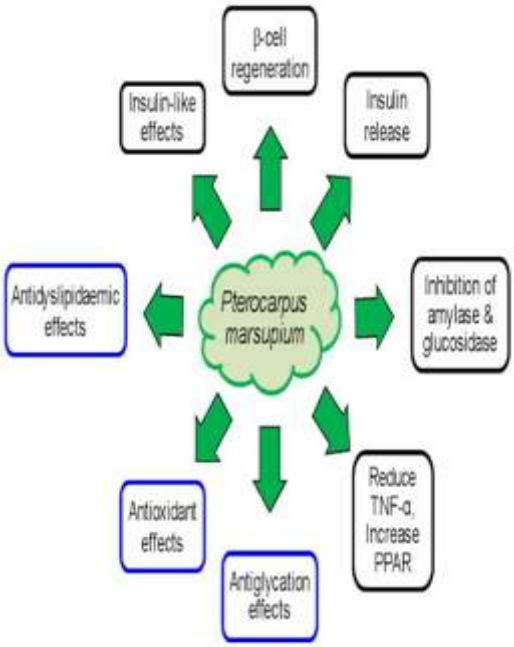

Fig-4 antidiabetic activities .

Anti-diabetic activity :

The antidiabetic and other pharmacological activities of various parts of the P. marsupium are reported. An aqueous infusion along with ethanolic extract of P. marsupium heart wood is widely known for hypoglycemic activity[33-34] It is postulated that antidiabetic activity of P. marsupium is the result of its ability to decrease glucose absorption from the gastrointestinal tract that leads to improve insulin and pro-insulin levels in the blood. P. marsupium has also been documented to help in regeneration of pancreatic β-cells[35,36]. The active antidiabetic ingredients in the aqueous extract has been identified as (-) epicatechin, a benzopyran which on administration to alloxan-induced diabetic rats increased insulin secretion and number of islets in the pancreas. Insulin like activity of (-) epicatechin has been reported[37]. (-) epicatechin isolated from the bark

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

Fig-5[P. Marsupium]

Fig –6[Aegle marmelos (L.)]

of P. marsupium was found to have protective and restorative effects . Heartwood of P.marsupium has also been tested clinically and found effective in non insulin dependent diabetes mellitus patients (Type 2DM). The present study is a confirmation towards establishing antidiabetic activity of aqueous and ethanolic extracts of the heart wood of P.marsupium in validated animal models of type 2 diabetes and analysis of the phytoconstituents of P. marsupium.

4. Aegle marmelos (L.)

Plant profile

I. Botanical Name: Aegle Marmelos
II. Sanskrit Name: Bilva
III. English Name: Bael Tree
IV. Family: Rutaceae
V. Parts of Plant used: Fruit, leaf, root, bark

Scientific classification

I. Order: Sapindales
II. Family: Rutaceae
III. Subfamily: Aurantioideae
IV. Tribe: Clauseneae
V. Genus: Aegle Corrêa
VI. Species: A. marmelos
VII. Binomial name: Aegle marmelos (L.)

Aegle marmelos is widely used in Indian Ayurvedic medicine for the treatment of diabetes mellitus63

Antidiabetic activity

Antidiabetic mode of action is of multidirectional as the extract can significantly lower the levels of blood glucose and glycosylated hemoglobin and increased the plasma insulin as well as liver glycogen in diabetic rats65. The leaf extract at a dose of 250mg/kg exhibited to be more effective than glibenclamide, a well-known hypoglycemic drug. This antidiabetic effect is probably due to the presence of eugenol and marmesin in bael leaves extract suggesting antioxidant potential of the leaves which potentiate the insulin secretion from existing beta cells of the islets of Langerhans66. It was further proved that aqueous leaf extract of Aegle marmelos have anti hypoglycemic activity, as the aqueous extract of the Aegle marmelos leaves were found to inhibit primarily the uptake of glucose across rat inverted gut sacs67.

The leaf extracts appears to be inhibiting glucose-6-phosphate , hepatic glucose output and controlling the elevated blood glucoselevels. Aegle marmelos leaf is an insulin sensitizer which can be used in the treatment of diabetes. It improves the glycemic control by enhancing the insulin sensitivity in liver and muscle6

5. Ocimum tenuiflorum

The species of this genus which mostly show significant antihyperglycemic effects are Ocimum tenuiflorumL., Ocimum basilicum L., Ocimum gratissimum L. and Ocimum canum L.

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

The results were shown in both in vitro and in vivo studies. The anti-hyperglycemic activities of different extracts from all these species are reported here. Aqueous extracts are common to show a satisfactory result for all the species.

Fig –7 [Ocimum tenuiflorum]

Phytochemistry

The phytochemistry of Ocimum sanctum is identified in all parts of this plant, containing many nutrients and bioactive constituents. However, the quantity of these constituents depends on many natural factors, including growing, harvesting, storage conditions [39,40].

In leaf extract of O. sanctum, volatile oil was extracted and identified chemical compositions, containing many major components like eugenol, methyleugenol, and p-caryophylen. The essential oil of this herb contains various bioactive compounds, such as terpenoids, esters, aliphatic aldehydes and phenolic acids. This herb also consists of a diversity of second metabolites, including phenolics, flavonoids, terpenoids, lignans, steroids, fatty acids and their derivatives. These components have been mainly studied for therapeutic purposes because of their biological and pharmacological effects, including antioxidant, anti-inflammatory, antimicrobial, anticancer and antidiabetic activity

Antidiabetic Activity

In Hannan's study, there are four fractions of Ocimum sanctum including the ethanol, aqueous, butanol, and ethyl acetate fractions prepared to elucidate the mechanism of antihyperglycemic activity of this plant showed in literature [41]. This result proved that these fractions could stimulate insulin secretion. This study also indicates that the ethanol extract could decrease blood glucose concentration and increase insulin secretion, thereby this plant is a potential herb in diabetic treatment. Moreover, by in vivo experiment, the O. sanctum extract was showed to be able to improve oral glucose tolerance, decrease serum glucose, increase glycogen synthesis in the liver [42].

It was reported that leaf power extract lowered plasma glucose level by the presence of many active phytochemicals including eugenol, carvacrol, linalool, caryophylline, β-sitosterol which have been studied about potent hypoglycemic effects efficiency [43]. The other investigation has reported the antidiabetic and hypoglycemic activities of a triterpenoid (16-hydroxy-4,4,10,13-tetramethyl-17-(4-methyl-pentyl)- hexadecahydro-cyclopenta[a]phenanthrene-3-one) isolated from Ocimum sanctum by in vivo investigation [44]. The mechanisms of the antidiabetic and hypoglycemic potential of this compound were elucidated to increase the pancreatic secretion of insulin from β-cells, and enhance glucose utilization [44]. It was suggested that this triterpenoid should be considered to be developed as a potential antidiabetic medicine. This evidences support that O. sanctum has many benefits in the management of diabetes, and this plant should be encouraged to be a potential anti- diabetic activity [45].

6. Syzygium cumini

Scientific classification

I. Kingdom:Plantae
II. Clade:Tracheophytes
III. Clade:Angiosperms
IV. Clade:Eudicots
V. Clade:Rosids
VI. Order:Myrtales
VII. Family:Myrtaceae
VIII. Genus:Syzygium
IX. Species:S. Cumini

Fig-8 [Syzygium cumini]

The Syzygium cumini (or Eugenia jambolana) tree belongs to the Myrtaceae family. This is also called a Jamun, Jambul and Jambool in

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

India and Malaya. The barks, leaves and seeds extracts of SC have been reported to possess anti-inflammatory (46] antibacterial and anti-diarrheal effects (46]. The present study was designed to evaluate the anti-diabetic activity of isolated compound mycaminose, EA and ME extracts of the SC seeds against STZ-induced diabetic rats. The effect of SC extracts was compared to glibenclamide, which is often used as a standard drug.

Use of S. cumini in the fight against diabetes has been studied by western medicine since more than 130 years [47]. In recent years, numerous preclinical studies have evaluated extracts of various parts, especially seeds, of this plant species for anti- hyperglycemic activity [48];[49]. Blood and urine glucose levels of streptozotocin- induced diabetic rats were decreased upon 30-days treatment with ethanolic extract of seed at doses of 100 mg/kg/day. In addition to blood glucose lowering effect, flavonoid-rich extract of seed was also shown to recover peripheral glucose tolerance in streptozotocin-induced diabetic rats (500 mg/kg/day, 21 day) and mice (300 mg/kg/day, 15 days) (Sharma et al., 2008b).

7. Trigonella foenum- graecum

Fenugreek is an aromatic plant that has many uses, both culinary – fenugreek is a key ingredient of curries and other Indian recipes – and medicinal.The plant, which is widely grown in South Asia, North Africa and parts of the Mediterranea, has small round leaves and also produces long pods that contain distinctive bitter-tasting seeds."The leaves are either sold as a vegetable (fresh leaves, sprouts, and microgreens) commonly known as methi, or as an herb (dried leaves), while the seeds are used both whole and in powdered form as a spice.

Fig –9 [trigonella foenum graecum]

Anti-daibetic effect

Fenugreek seeds (trigonella foenum graecum) are high in soluble fibre, which helps lower blood sugar by slowing down digestion and absorption of carbohydrates This suggests they may be effective in treating people with Multiple studies have been carried out to investigate the potential anti-diabetic benefits of fenugreek.Of these, several clinical trials showed that fenugreek seeds can improve most metabolic symptoms associated with both type 1 and type 2 diabetes in humans by lowering blood glucose levels and improving glucose tolerance In one study, researchers in India found that adding 100 grams of defatted fenugreek seed powder to the daily diet of patients with insulin-dependent (type 1) diabetes significantly reduced their fasting blood glucose levels, improved glucose tolerance and also lowered total cholesterol, LDL or 'bad' cholesterol and triglycerides In another controlled trial, incorporating 15 grams of powdered fenugreek seed into a meal eaten by people with type 2 diabetes reduced the rise in post-meal blood glucose, while a separate study found that taking 2.5 grams of fenugreek twice a day for three months lowered blood sugar levels in people with mild, but not severe, type 2 diabetes.

8. Azadirachta indica

Azadirachta indica (Neem) is a medicinal plant, used in Ayurveda for treating various diseases, one of which is diabetes mellitus. It is known to possess antiinflammatory, antipyretic, antimicrobial, antidiabetic and diverse pharmacological properties. However, the molecular mechanism underlying the effect of A. indica on insulin signal transduction and glucose homeostasis is obscure.

Fig-10[Azadirachta indica]

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

Azadirachta indica A. Juss (Family Meliaceae) is well known in India and its neighboring countries as one of the most versatile medicinal plants havingwide spectrum of biological activity. Each part of Neem tree has some medicinal property and thus commercially exploitable.[52] A. indica is known to possess antiinflammatory, antipyretic, antimicrobial, antidiabetic and diverse pharmacological properties. During the last five decades, considerable progress has been achieved regarding the biological activity and medicinal application of A. indica A Juss (Neem).

A. indica has been commonly used to treat diabetes in Indian system of medicine from time immemorial. There are several reports that suggest the hypoglycemic potential of A. indica.[Leaf and bark extract of A. indica had been shown to reduce blood glucose level and lipid peroxidantion and increased the antioxidant enzymes such as superoxide dismutase, catalase, and glutathione peroxidase in liver.

Anti-dabietic activity

Treatment with A. indica leaf aqueous extract to high-fat diet-induced diabetic Charles foster rats for 30 days, significantly increased the activities of enzymatic antioxidants in hepatic tissues suggesting that A. indica leaf extract has both antidiabetic and antioxidant potentials.[53] Moreover, chronic treatment with ethanolic extract of A. indica has been shown to reduce the blood glucose level and ameliorates lesions of pancreatic islets in streptozotocin-induced diabetic rats.[54,55]However, the molecular mechanisms underlying anti-diabetic potentials of A. indica on insulin signaling molecules and glucose oxidation have not been studied so far. Hence, the present study was undertaken to appraise the molecular events by which A. indica exhibits antidiabetic action in type-2 diabetic male Wistar rats.

9. Panax ginseng C.A Meyer

In Korea, Ginseng is the most famous traditional plant used in folk medicine for a long time . Ginseng belongs to the genus Panax in family Araliaceae [56]. It distributes typically in a cooler climate region that can be rt The root of this plant contains many bioactive compounds, including triterpene glycosides, or saponins, commonly referred to as ginsenosides, Panaxans, vanillic acid, salicylates. All parts of the plant also have some active constituent, such as amino acids, alkaloids, phenols, proteins, polypeptides, and vitamins B1 and B2 which have been identified [56,57,58].

Fig –11 [Panax ginseng C.A Meyer]

Antidiabetic Activity

Since diabetes mellitus is characterized by insulin resistance, and β-cell dysfunction, therapeutic medications should be involved in improving insulin resistance, enhancing glucose uptake, decreasing blood glucose concentration, and protecting/regenerating β-cell from pancreatic islets. Many researchers have been investigated the anti-diabetic activities on the root of Panax ginseng in vitro and in vivo experiments [59,60,61]. The most important group of phytochemicals f Panax ginseng is ginseng-specific saponins called ginsenosides. Among them, Ginsenosied Rb2 was the most effective constituent treated for streptozotocin-induced diabetic rats by decreasing blood glucose level . Moreover, in fermented red ginseng extracts, the content of ginsenoside Rg2, Rg3, and Rh2 are higher than normal ginseng so that those extracts significantly reduced blood glucose levels and increased plasma insulin levels in streptozotocin-induced diabetic rats by orally-administered 100 or 200 mg/kg extracts dissolved in water, at 10 a.m. daily in three weeks [**62]**. These mechanisms have been displayed in **Figure 6**. In general, saponins, which were isolated from ginseng that has been proven significant antidiabetic activity. The mechanism of these components in antidiabetic treatment is to moderate the enzyme activity [63] to influence glucose metabolism and control insulin secretion.

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

10. Aloe vera L. Burm. (Asphodelaceae)

Aloe vera is the popularly medicinal plant ever known and the most applied medicinal plant especially in the cosmetic industry, and antidiabetic mediation (**Figure 8**). This traditional medicinal plant belongs to the family Liliaceae. It is original to Africa and Mediterranean countries. It is reported to be distributed widely in the islands of Cyprus, Malta, Sicily, Cape Verde and India [64].

Fig –12 [**Aloe vera L. Burm.]**

Phytochemistry

Phytoconstituents in the plant are alkaloids, flavonoids, tannins, phenols, saponins, carbohydrates, vitamins and minerals and several other aromatic compounds [65]. These compounds have been proven for various pharmacological activities, such as antioxidant, antimicrobial, antidiabetic, anti-cancer and so on. That is the result why until now scientists continue to investigate biological activities of this plant to production modern medicine and traditional medicine.

Antidiabetic Activity

The experiment on diabetic rats treated with Aloe vera water extract orally led to reducing significant blood glucose levels. Statistical analysis of results found that Aloe vera water extract is antidiabetic with fewer side effects [66,67]. Moreover less expensive cost is also a significant benefit of Aloe vera in the production of medicine against diabetes mellitus.

11. Zingiber officinale Rosc (Ginger)

It is a traditionally flowering spicy plant in the family Zingiberaceae which was originally native to southern China, and has been grown in many countries in the tropical and subtropical areas, from East Asia to Southeast Asia and South Asia. All parts of this plant, including rhizome, ginger root are widely used as essential food spices or traditional medicine [68,69].

Fig –13[Zingiber officinale Rosc]

Phytochemistry

The phytochemicals of ginger are quite different depending on the origin and the fresh or dry state of parts of this herb. The phytochemicals of rhizome ginger contain strong free-radical reducing efficacy. They include volatile oils, phenolic compounds and others. Among them, volatile oils, also known as ginger essential oils, are a mixture of terpenoid compounds, including sesquiterpene hydrocarbons, monoterpene hydrocarbons, carbonyl compounds, alcoholsand esters. Especially, the phenolics in ginger are the most important components. The phenolic constituents were divided into two groups: gingerol-, gingeron- and shogaol-related group and diarylheptanoids. Gingerol which is the spicy component of this plant contains a diversity of various bioactive substances. Besides, this plant also contains a variety of amino acids, including glutamate, aspartic acid, serine, glycine, threonine, alanine, etc. Moreover, ginger also contains polysaccharides and organic acids, such as oxalic acid, tartaric acid, etc. [68,69,70].

Antidiabetic Activity

Sharma and Shukla reported that ginger juice can lower blood glucose concentration in normal fasting animals and in alloxan diabetic animals [7**1**]. The mechanism of lowering the glucose effect was explained because it can increase the viscosity of gastrointestinal contents, slow gastric emptying and also acts as a barrier to diffusion. Other studies also demonstrated that folk medicinal plant ginger can control tissue glycogen content in diabetic rats by improving the peripheral utilization of glucose and repairing the impaired liver [72].

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

Moreover, the rhizome of Zingiber officinale Rosc also proved that its bioactive components can enhance glucose uptake in cultured L6 myotubes [73]. That investigation suggested that the phenolic gingerol constituents were the major active compounds enhancing glucose uptake. Other investigations showed that the solution of the fresh ginger sample exhibited inhibition against alpha-amylase and alpha-glucosidase activities and inhibit angiotensin-converting enzyme [74,75].

Furthermore, powder of ginger can decrease the level of glucose and activate inflammatory activity which can lead to the development of insulin resistance [76].

Marketed preparation of polyherbal anti-diabetic tablet

Sr.no	product	Manufacturer	Mechanism
1	Sharang Dyab-T	Plant Med.Lab pvt.Ltd	Stimulate insulin production
2	Herbal hills Jambu	Isha Agro Developers	Reduce blood and urine sugar level
3	Stevia-33	Vitalize Herbs Pvt.Ltd	Stimulate B-cell of pancreas
4	Diab-FIT	Herbal FIT	Maintain proper blood sugar level
5	Madhumar Capsule	Kangrd Hills Care and Cure product	Control chronic diabetes mellitus
6	Glucomap	Maharishi Ayurveda	Redeuces HbA1C, fasting and post meal blood sugar levels
7	Gymne-Mag D	NatXtra	Regulate blood sugar level
8	Diabiant	Ambic	Regulate blood glucose
9	GLUCOCARE	Himalaya	Promotes blood sugar level
10	KARELA	Merlion- naturals	Control diabetic mellitius

III. CONCLUSION

Diabetes mellitus has been considered to be a major cause affecting the economy of patients, their families and society. Furthermore, uncontrolled diabetes leads to serious chronic complications such as blindness, kidney failure, and heart failure. In order to decrease this problem, researches on new antidiabetic agents are concerned. Because of the adverse effects of modern therapies, many traditional medicines have been noticed. Moreover, herbal extracts nowadays can be used with standard drugs for combinatorial therapies. Each herb has its own active ingredients that can lower blood sugar levels as well as control

the complications of diabetes. Future research will focus on isolation, purification, and identification of bioactive substances in plants. This review is looking forward to providing the necessary information in the management of diabetes. In our review, we have introduced a complete list of anti-diabetic plants taken from the Vietherb database [77]. Isolation and identification of bioactive phytochemicals from these plants play an important role in improving insights into anti-diabetic functional food [78] and drug development [79].

REFERENCE

[1]. Habibullah Khan M and Yadava PS. Antidiabetic plants used in Thobal district of Manipur, Northeast India, Indian journal of traditional knowledge, 2002; 9(3): 510-514.
[2]. Anonymous, traditional medicine strategy. WHO,2002-2005; WHO/EDM/TRM/2002.1.
[3]. Patrick OE. Herbal medicines: challenges. Tropical J Pharmaceutics Res, 2005; 1(2): 53-54.
[4]. Awadh A, Ali N, Al-rahwi IK and Lindequist U. Some medicinal plants used in Yemeni herbal to treat malaria. Afr J Traditional complement Alt Med., 2004; 1: 72-76.
[5]. Kala CP. Ethno medicinal botany of the Apatani in the Eastern Himalayan region of India. J Ethnobiol Ethnomed, 2005; 1(11): 1-8.
[6]. Grover JK and Vats V. Shifting Paradigm from conventional to alternate medicine. An introduction on traditional Indian medicine, Asia Pacific Biotechnology News, 2001
[7]. Malik JK, Thacker AM and Ahmed A. Ethnoveterinary medicine in western India, Ethnoveterinary Research and Development, Edited by Mc Corkle C, (Intermediate Technology Publication, UK), 1996; 148.
[8]. Kattamani KN, Munikrishnappa MP, Husain SA and Reddy PN. Use of plants as medicine under semi-arid tropical climate of Raichur district of North Karnataka, J Med Aromat Pl Sci, 2000; 22-23: 406-410.
[9]. WHO expert consultation. Report of the expert committee on the diagnosis
[10]. and classification of diabetes mellitus. Diabetes Care 2002; 25: 5–20.
[11]. Newman B., Selby J. V., King M. C., Slemenda C., Fabsitz, R., Friedman, G. D. Concordance for type 2 (non-insulindependent) diabetes mellitus in male twins. Diabetology 1987; 30: 763–768. Doi: 10.1007/BF00275741.
[12]. Kaprio J., Tuomilehto J., Koskenvuo M., Romanov K., Reunanen A., Eriksson J. et al. Concordance for type 1 (insulin-dependent) and type 2 (non-insulin dependent) diabetes mellitus in a population-based cohort of twins in Finland. Diabetology 1992; 35: 1060–1067. Doi: 10.1007/BF02221682.
[13]. Bellamy L., Casas J. P. Hingorani, A. D. Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. Lancet 2009; 373: 1773–1779. Doi: 10.1016/S0140-6736(09)60731-5.
[14]. WHO. Global report on diabetes 2016; Geneva: WHO.
[15]. Chadha, Y.R. The wealth of India, New Delhi: Publications and informations directorate. CSIR **1976**, X, 582. [**Google Scholar**]
[16]. Yousaf, Z.; Masood, S.; Shinwari, Z.K.; Khan, M.A.; Rabani, A. Evaluation of taxonomic status of medicinal species of the genus Hyoscyamous, Withania, Atropa and Datura based on polyacrylamide gel electrophoresis. Pak. J. Bot. **2008**, 40, 2289–2297. [**Google Scholar**]
[17]. Watt, G.A. Dictionary of the Economic Products of India; Cosmo Publications: Delhi, India, 1972; Volume 6, p. 309. [**Google Scholar**]
[18]. Mathur, D.; Agrawal, R. Withania coagulans: A review on the morphological and pharmacological properties of the shrub. Sci. World
[19]. J. **2011**, 1, 30–37. [**Google Scholar**]
[20]. Rahman, A.U.; Abbas, S.; Shahwar, D.E.; Jamal, S.; Choudhary, M. New withanolides from Withania spp. J. Nat. Prod. **1993**, 56, 1000– 1006. [**Google Scholar**] [**CrossRef**]
[21]. Atta-ur-Rahman; Choudhary, M.I.; Qureshi, S.; Gul, W.; Yousaf, M. Two new ergostane-type steroidal lactones from Withania coagulans.J. Nat. Prod. **1998**, 61, 812–814. [**Google Scholar**] [**CrossRef**]
[22]. Kuroyanagi, M.; Murata, M.; Nakane, T.; Shirota, O.; Sekita, S.; Fuchino, H.;

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

Shinwari, Z.K. Leishmanicidal active withanolides from a Pakistani medicinal plant, Withania coagulans. Chem. Pharm. Bull. **2012**, 60, 892–897. [**Google Scholar**] [**CrossRef**][**Green Version**]

[23]. Verma, P.K.; Rajurkar, S.; Gaikwad, N.; Kamboj, V. The isolation and structure elucidation of new Withanaoloides from Withania cogulance with antidiabetic activity. Acta Pharm. Sci. **2010**, 52, 155–157. [**Google Scholar**]

[24]. Li, W.L.; Zheng, H.C.; Bukuru, J.; De Kimpe, N. Natural medicines used in the traditional Chinese medical system for therapy of diabetes mellitus. J. Ethnopharmacol. **2004**, 92, 1–21. [**Google Scholar**] [**CrossRef**] [**PubMed**]

[25]. Rathi, S.S.; Grover, J.K.; Vats, V. The effect of Momordica charantia and Mucuna pruriens in experimental diabetes and their effect on key metabolic enzymes involved in carbohydrate metabolism. Phytother. Res. **2002**, 16, 236–243. [**Google Scholar**] [**CrossRef**] [**PubMed**]

[26]. Saeed, F.; Afzaal, M.; Niaz, B.; Arshad, M.U.; Tufail, T.; Hussain, M.B.; Javed, A. Bitter melon (Momordica charantia): A natural healthy vegetable. Int. J. Food Prop. **2018**, 21, 1270–1290. [**Google Scholar**] [**CrossRef**][**Green Version**]

[27]. Khanna, P.; Jain, S.C.; Panagariya, A.; Dixit, V.P. Hypoglycemic activity of polypeptide-p from a plant source. J. Nat. Prod. **1981**, 44, 648–655. [**Google Scholar**] [**CrossRef**]

[28]. Dans, A.M.; Villarruz, M.V.; Jimeno, C.A.; Javelosa, M.A.U.; Chua, J.; Bautista, R.; Velez, G.G.B. The effect of Momordica charantia capsule preparation on glycemic control in type 2 diabetes mellitus needs further studies. J. Clin. Epidemiol. **2007**, 60, 554–559. [**Google Scholar**] [**CrossR**

[29]. Keller, A.C.; Ma, J.; Kavalier, A.; He, K.; Brillantes, A.M.;Kennelly,

[30]. E.J. Saponins from the traditional medicinal plant Momordica charantia stimulate insulin secretion in vitro. Phytomedicine **2011**, 19, 32–37. [**Google Scholar**] [**CrossRef**] [**PubMed**][**Green Version**]

[31]. Sasa, M.; Inoue, I.; Shinoda, Y.; Takahashi, S.; Seo, M.; Komoda, T.; Awata, T.; Katayama, S. Activating effect of momordin, extract of bitter melon (Momordica Charantia L.), on the promoter of human PPAR delta. J. Atheroscler. Thromb. **2009**, 16, 888–892. [**Google Scholar**] [**CrossRef**]

[32]. Khanna, P.; Jain, S.C.; Panagariya, A.; Dixit, V.P. Hypoglycemic activity of polypeptide-p from a plant source. J. Nat. Prod. **1981**, 44, 648–655. [**Google Scholar**] [**CrossRef**]

[33]. Dans, A.M.; Villarruz, M.V.; Jimeno, C.A.; Javelosa, M.A.U.;Chua, J.; Bautista, R.; Velez, G.G.B. The effect of Momordica charantia capsule preparation on glycemic control in type 2 diabetes mellitus needs further studies. J. Clin. Epidemiol. **2007**, 60, 554–559. [**Google Scholar**] [**CrossRef**]

[34]. Kar A, Choudhary B K & Bandyopadhyay N G, Comparative evaluation of hypoglycemic activity of some Indian medicinal plants in alloxan diabetic rats, J Ethnopharmacol, 84 (2003) 105.

[35]. 2 Grover J K, Vats V & Yadav S, Effect of feeding aqueous extract of Pterocarpus marsupium on glycogen content of tissues and the key enzymes of carbohydrate metabolism, J Mole Cell Biochem, 241 (2002) 53

[36]. Maruthupandian A & Mohan V R, Antidiabetic, antihyperlipidemic and antioxidant activity of Pterocarpu marsupium Roxb. in alloxan-induced diabetic rats, Int J Pharmatech Research, 3 (2011) 1681.

[37]. Patil U H & Gaikwad D K, Pterocarpus marsupium: A valuable medicinal plant in diabetes management, Int J Appl Biol and Pharmac Tech, 2 (2011)

[38]. Chakravarthy B K, Gupta S, Gambhir S S & Gode K D, Pancreatic beta- cell regeneration- A noval antidiabetic

[39]. mechanism of Pterocarpus marsupium, Roxb., Indian J Pharmac, 12 (1980) 123.

[40]. Ahmad F, Khalid P, Khan M M, Rastogi A K & Kidwai J R, Insulin like activity in (-)-epicatechin, Acta Diabetologica Lat, 26 (1989) 291.

[41]. Chakravarthy B K, Gupta S, Gambhir, S S & Gode K D, The prophylactic action of (-)-epicatechin against alloxan induced diabetes in rats, Life Science, 29 (1982) 2043.

[42]. Rahman, S.; Islam, R.; Kamruzzaman,

Md.; Alam, M.K. Ocimum sanctum L.: A review of phytochemical and pharmacological profile. Am. Drug Discov. Dev. **2011**, 1–15. [**Google Scholar**] [**CrossRef**]

[43]. Singh, D.; Chaudhuri, P.K. A review on phytochemical and pharmacological properties of Holy basil (Ocimum sanctum L.). Ind. Crops Prod. **2018**, 118, 367–382. [**Google Scholar**] [**CrossRef**]

[44]. Hannan, J.M.; Marenah, L.; Ali, L.; Rokeya, B.; Flatt, P.R.; Abdel- Wahab, Y.H. Ocimum sanctum leaf extracts stimulate insulin secretion from perfused pancreas, isolated islets and clonal pancreatic beta-cells. J. Endocrinol. **2006**, 189, 127–136. [**Google Scholar**] [**CrossRef**] [**PubMed**][**Green Version**]

[45]. Hannan, J.M.A.; Ojo, O.O.; Ali, L.; Rokeya, B.; Khaleque, J.; Akhter, M.; Flatt, P.R.; Abdel-Wahab, Y.H.A. Actions Underlying Antidiabetic Effects of Ocimum sanctum Leaf Extracts in Animal Models of Type 1 and Type 2 Diabetes. Eur. J. Med. Plants **2014**, 5, 1–12. [**Google Scholar**] [**CrossRef**]

[46]. Lakshmi, M.S.; Rani, K.S.S.; Reddy, U.T.K. A Review on Diabetes Mellitus and the Herbal Plants Used for Its Treatment. Asian J. Pharm. Clin. Res. **2012**, 5, 15–21. [**Google Scholar**]

[47]. Patil, R.; Patil, R.; Ahirwar, B.; Ahirwar, D. Isolation and characterization of anti-diabetic component (bioactivity-guided fractionation) from Ocimum sanctum L. (Lamiaceae) aerial part. Asian Pac. J. Trop. Med. **2011**, 4, 278–282. [**Google Scholar**] [**CrossRef**][**Green Version**]

[48]. Chaudhuei AKN, Pal S, Gomes A, Bhattacharya S (1990). Anti-inflammatory and related actions od Syzygium cumini seed extract. Phytotherphy Research. 4: 5–10.

[49]. Indira G, Mohan RM (1992). Fruits. National Institute of Nutrition, IndianCouncil of Medical Research, Hyderabad, India. pp.34 – 37.Kim SH, Hyun SH and Choung SY (2006). Anti-diabetic effect ofcinnamon extract on blood glucose in db/db mice. J. Ethnopharmacol.104, 119 – 123

[50]. Helmstadter, A. (2008). Syzygium cumini (L.) SKEELS (Myrtaceae) against diabetes–125 years of research. Pharmazie 63, 91–101.

[51]. Ravi, K., Rajasekaran, S., and Subramanian, S. (2003). Hypoglycemic effect of Eugenia jambolana seed kernels on streptozotocin-induced diabetes in rats. Pharm. Biol. 41, 598–603. doi: 10.1080/13880200390501929

[52]. Silva, S. D. N., Abreu, I. C., Silva, G. F. C., Ribeiro, R. M., Lopes, A. D. S., Cartágenes, M. D. S. D. S., et al. (2012). The toxicity evaluation of Syzygium cumini leaves in rodents. Rev. Bras. Farm. 22, 102–108. doi: 10.1590/S0102-695X2011005000181

[53]. Sharma, B., Viswanath, G., Salunke, R., and Roy, P. (2008b). Effects of flavonoid-rich extract from seeds of Eugenia jambolana (L.) on carbohydrate and lipid metabolism in diabetic mice. Food Chem. 110, 697–705. doi: 10.1016/j.foodchem.2008.02.068

[54]. Biswas K, Chattopadhyay I, Banerjee RK, Bandyopadhyay V. Biological and medicinal properties of Neem (Azadirachta indica) Curr Sci.

[55]. 2002;82:1136–45. [Google Scholar]

[56]. Shrivastava A, Chaturvedi U, Sonkar R, Khanna AK, Saxena JK, Bhatia G. Antioxidant effect of Azadirachta indica on high fat diet induced diabetic Charles Foster rats. Appl Biochem Biotechnol. 2012;167:229–36. [PubMed] [Google Scholar]

[57]. Akinola O, Ezekiel A, Dini CM. Diabetes-induced prefrontal nissl substance deficit and the effects of Neem-Bitter leaf extract treatment. J Morphol. 2010;28:291–302. [Google Scholar]

[58]. Akpan HD, Ekaidem IS, Usoh IF, Ebong PE, Isong NB. Effect of aqueous extract of Azadirachta indica (Neem) leaves on some indices of pancreatic function in alloxan-induced diabetic wistar rats. Pharmacologia. 2012;3:420–5. [Google Scholar]

[59]. Attele, A.S.; Zhou, Y.P.; Xie, J.T.; Wu, J.A.; Zhang, L.; Dey, L.; Pugh, W.; Rue, P.A.; Polonsky, K.S.; Yuan, C.-S. Antidiabetic effects of Panax ginseng berry extract and the identification of an effective component. Diabetes **2002**, 51, 1851–1858. [**Google Scholar**] [**CrossRef**][**Green Version**]

[60]. Park, J.D.; Rhee, D.K.; Lee, Y.H.

International Journal of Pharmaceutical Research and Applications
Volume 8, Issue 1 Jan-Feb 2023, pp: 1926-1940 www.ijprajournal.com ISSN: 2249-7781

Biological Activities and Chemistry of Saponins from Panax ginseng C. A. Meyer. Phytochem. Rev. **2005**, 4, 159–175. [**Google Scholar**] [**CrossRef**][**Green Version**]

[61]. Ratan, Z.A.; Haidere, M.F.; Hong, Y.H.; Park, S.H.; Lee, J.-O.; Lee, J.; Cho, J.Y. Pharmacological potential of ginseng and its major component ginsenosides. J. Ginseng Res. **2020**. [**Google Scholar**] [**CrossRef**]

[62]. Konno, C.; Murakami, M.; Oshima, Y.; Hikino, H. Isolation and hypoglycemic activity of panaxans Q, R, S, T and U, glycans of Panax ginseng roots. J. Ethnopharmacol. **1985**, 14, 69–74. [**Google Scholar**] [**CrossRef**]

[63]. Kimura, M.; Waki, I.; Tanaka, O.; Nagai, Y.; Shibata, S. Pharmacological sequential trials for the fractionation of components with hypoglycemic activity in alloxan diabetic mice from ginseng radix. J. Pharmacobiodyn. **1981**, 4, 402–409. [**Google Scholar**] [**CrossRef**] [**PubMed**][**Green Version**]

[64]. Yokozawa, T.; Kobayashi, T.; Oura, H.; Kawashima, Y. Studies on the mechanism of the hypoglycemic activity of ginsenoside-Rb2 instreptozotocin- diabetic rats. Chem. Pharm. Bull. **1985**, 33, 869–872. [**Google Scholar**] [**CrossRef**][**Green Version**]

[65]. Kim, H.-J.; Chae, I.-G.; Lee, S.-G.; Jeong, H.-J.; Lee, E.-J.; Lee, I.-S. Effects of Fermented Red Ginseng Extracts on Hyperglycemia in Streptozotocin-induced Diabetic Rats. J. Ginseng Res. **2010**, 34, 104–112. [**Google Scholar**] [**CrossRef**][**Green Version**]

[66]. Dans, A.M.; Villarruz, M.V.; Jimeno, C.A.; Javelosa, M.A.U.;Chua, J.; Bautista, R.; Velez, G.G.B. The effect of Momordica charantia capsule preparation on glycemic control in type 2 diabetes mellitus needs further studies. J. Clin. Epidemiol. **2007**, 60, 554–559. [**Google Scholar**] [**CrossRef**]

[67]. Ali, A.M. Effect of aloes on blood glucose levels in normal and alloxan diabetic mice. J. Ethnopharmacol. **1990**, 28, 215–220. [**Google Scholar**]

[68]. Patel, D.K.; Patel, K.; Dhanabal, S.P. Phytochemical standardization of Aloe vera extract by HPTLC technique. J. Acute Dis. **2012**, 47–50. [**Google Scholar**] [**CrossRef**][**Green Version**]

[69]. Yimam, M.; Zhao, J.; Corneliusen, B.; Pantier, M.; Brownell, L.; Jia, Q. Blood glucose lowering activity of aloe based composition, UP780, in alloxan induced insulin dependent mouse diabetes model. Diabetol. Metab. Syndr.**2014**, 6, 61. [**Google Scholar**] [**CrossRef**][**Green Version**]

[70]. Kim, K.; Kim, H.; Kwon, J.; Lee, S.; Kong, H.; Im, S.-A.; Lee, Y.-H.; Lee, Y.-R.; Oh, S.-T.; Jo, T.H.; et al. Hypoglycemic and hypolipidemic effects of processed Aloe vera gel in a mouse model of non-insulin-dependent diabetes mellitus. Phytomedicine **2009**, 16,

[71]. Ali, B.H.; Blunden, G.; Tanira, M.O.; Nemmar, A. Some phytochemical, pharmacological and toxicological properties of ginger (Zingiber officinale Roscoe): A review of recent research. Food Chem. Toxicol. **2008**, 46, 409–420. [**Google Scholar**] [**CrossRef**]

[72]. Imtiyaz, S.; Rahman, K.; Sultana, A.; Tariq, M.; Chaudhary, S.S. Zingiber officinale Rosc.: A traditional herb with medicinal properties. Tang **2013**, 3. [**Google Scholar**] [**CrossRef**]

[73]. Liu, Y.; Liu, J.; Zhang, Y. Research Progress on Chemical Constituents of Zingiber officinale Roscoe. Hindawi BioMed Res. Int. **2019**, 5370823. [**Google Scholar**] [**CrossRef**][**Green Version**]

[74]. Sharma, M.; Shukla, S. Hypoglycaemic effect of ginger. J. Res. Indian Yoga Homoeop. **1977**, 12, 127–130. [**Google Scholar**]

[75]. Abdulrazaq, N.B.; Cho, M.M.; Win, N.N.; Zaman, R.; Rahman, M.T. Beneficial effects of ginger (Zingiber officinale) on carbohydrate metabolism in streptozotocin-induced diabetic rats. Br. J. Nutr. **2012**, 108, 1194–1201. [**Google Scholar**] [**CrossRef**][**Green Version**]

[76]. Li, Y.; Tran, V.H.; Duke, C.C.; Roufogalis, B.D. Gingerols of Zingiber officinale enhance glucose uptake by increasing cell surface GLUT4 in cultured L6 myotubes. Planta Med. **2012**, 78, 1549–1555. [**Google Scholar**] [**CrossRef**][**Green Version**]

[77]. Oboh, G.; Akinyemi, A.J.; Ademiluyi, A.O.; Adefegha, S. Inhibitory effects of

aqueous extract of two varieties of ginger on some key enzymes linked to type-2 diabetes in vitro. J. Food Nutr. Res. **2010**, 49, 14–20. [**Google Scholar**]

[78]. Akinyemi, A.J.; Ademiluyi, A.O.; Oboh, G. Inhibition of angiotensin-1- converting enzyme activity by two varieties of ginger (Zingiber officinale) in rats fed a high cholesterol diet. J. Med. Food **2014**, 17, 317–323. [**Google Scholar**] [**CrossRef**] [**PubMed**]

[79]. Sahardi, N.F.N.M.; Makpol, S. Ginger (Zingiber officinale Roscoe) in the Prevention of Ageing and Degenerative Diseases: Review of Current Evidence. Evid. Based Complement. Altern. Med. **2019**, 5054395. [**Google Scholar**] [**CrossRef**] [**PubMed**][**Green Version**]

[80]. Nguyen-Vo, T.-H.; Le, T.; Pham, D.; Nguyen, T.; Le, P.; Nguyen, A.; Nguyen, T.; Nguyen, T.-N.; Nguyen, V.; Do, H.; et al. VIETHERB: A Database for Vietnamese Herbal Species. J. Chem. Inf. Model. **2019**, 59, 1–9. [**Google Scholar**] [**CrossRef**]

[81]. Tran, N.; Tran, M.; Truong, H.; Le, L. Spray-drying microencapsulation of high concentration of bioactive compounds fragments from Euphorbia hirta L. extract and their effect on diabetes mellitus. Food **2020**, 9, 881. [**Google Scholar**] [**CrossRef**]

[82]. Thanh-Hoang, N.-V.; Loc, N.; Nguyet, D.; Thien-Ngan, N.; Khang, T.; Cao, H.; Le, L. Plant Metabolite Databases: From Herbal Medicines to Modern Drug Discovery. J. Chem. Inf. Model. **2020**, 60, 1101–1110. [**Google Scholar**]